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# Understanding trade-offs in upscaling and integrating climate-smart agriculture and sustainable river basin management in Malawi

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ABSTRACT

This paper presents an assessment of the potential trade-offs between social, economic and environmental objectives when upscaling and integrating climate-smart agriculture (CSA) with integrated catchment management (ICM) at landscape level, with a case study in Malawi. In a workshop, government and NGO representatives and experts assessed trade-offs between the goals of ICM and CSA under four different scenarios of climatic and economic changes. The paper presents a novel combination of scenarios and a trade-off matrix exercise to critically evaluate trade-offs between CSA and ICM and link these to policy challenges and interventions. Our analysis shows that the compatibility of CSA and ICM policies depends on future climatic and economic developments, with a higher prevalence of perceived trade-offs in futures with low economic growth and high climate change. CSA was expected to have limited effect on reducing inequalities and investment in literacy and skills development are critical to ensure that marginalised groups benefit from CSA.

## 1. Introduction

Smallholder farmers in Africa operate in a complex and unpredictable system of climatic, economic, political, environmental and social conditions and constraints (Denning et al., 2009; Lasco et al., 2014). Yields and farmer incomes are constrained by low soil quality, limited infrastructure and poor access to markets for inputs and produce (Giller et al., 2011; Lee et al., 2012). Smallholder farmers are targeted by multiple poverty alleviation and development strategies, including international food security and environmental initiatives and financing sources, such as the UNFCCC's Green Climate Fund and the Global Environmental Facility, in which the concept of Climate-Smart Agriculture (CSA) is gaining traction.

CSA has three objectives: (1) to sustainably increase productivity, (2) improve resilience and adaptive capacity, and (3) reduce and/or remove greenhouse gas emissions, where possible (FAO, 2013). CSA options include both on-farm and beyond-farm agricultural and landscape management activities, but also require addressing the mediating institutions, finance and policies (ibid.). Elements of agroforestry, conservation agriculture, livestock, aquaculture, post-harvest and food-energy systems are captured by the term CSA (FAO, 2015a). Whilst this broad scope has the advantage that CSA provides a common header for many disciplines and organisations, it has been criticised for failing to provide a compelling basis for transformation towards poverty alleviation or sustainable development and prioritisation of farmers' rights and knowledge (Neufeldt et al., 2011, 2013; Sugden 2015).

CSA proponents claim that because of its broadly supported goals, CSA should be upscaled, play a central role in agricultural strategies and be integrated with the wider social-ecological system to ensure effective use of resources (Sayer et al., 2013), for example, as pursued under the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). This requires coordination at farm or community levels, as well as landscape levels (Scherr et al., 2012). CSA would have to be integrated with existing landscape approaches, which have already been adopted in policy for several sectors (Reed et al., 2015). The Government of Malawi (GoM, 2015), where our study is situated, has adopted new national guidelines for Integrated Catchment Management (ICM), the country's preferred landscape approach to natural resource management and planning to stimulate economic development, social equity, and environmental sustainability (Hooper 2005, pp. 12–13). The ICM guidelines only include conservation agriculture and permaculture as suitable CSA practices under Sustainable Land Management practices.

Management at landscape scale arguably enables a holistic view of

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competing objectives and interests in land use, and understanding and addressing trade-offs (Freeman et al., 2015). The objectives of CSA and ICM are not necessarily compatible in formulation and implementation (Seppelt et al., 2013). Some objectives seem to align: for example, CSA adaptation through on-farm tree planting may contribute to ICM objectives of reducing run-off and increasing infiltration (Lasco et al., 2014). But much of the CSA and ICM debates take place within – rather than across – the agricultural and water sectors respectively (FAO, 2015b). Past implementation of catchment management and agriculture policies has resulted in conflicts, for example, where irrigated farming on river banks is preferred to increase farm revenues but negatively affects siltation mitigation. These trade-offs relate to physical possibilities as well as preferences, norms and values of decision-makers and their societies (O'Neill and Spash, 2000).

In the dynamic, complex, multi-level and multi-stakeholder context of CSA and ICM, scenario analysis can help to deal with complexity and uncertainties and identify practices and adaptive strategies that are robust to various contexts (Vervoort et al., 2014). Scenarios are defined as coherent descriptions of plausible hypothetical future situations, including the developments that may generate that future (Van Notten, 2006; Kosow and Gaßner, 2008). Scenarios can be based on alternative development pathways that arise from combinations of uncertain but important socio-economic, environmental and technological conditions (Swart et al., 2003). This may help to identify policies necessary to steer societies onto preferred development pathways. Each scenario and 'policy mix', however, is likely to encounter different trade-offs between policy objectives.

The aim of the scenario exercise presented here was to understand whether CSA can be successfully upscaled and contribute to ICM objectives under different district-level climate change and economic growth scenarios in Malawi. We investigated for each scenario what the perceived impacts of CSA on wellbeing of stakeholder groups were, the perceived policy and implementation trade-offs between CSA and ICM, and the main interventions deemed necessary to successfully harness CSA to meet economic, social and environmental policy goals.

## 2. Climate change and agriculture in Malawi

Malawi is at extreme risk of climate change because of its high levels of poverty, population density, exposure to climate-related events, and reliance on agriculture (Wheeler, 2011). Climate change predictions for Malawi from McSweeney et al. (2010) suggest that average temperatures may rise by 1.1 to 3.0 °C by the 2060s, and rainfall will decrease in the dry seasons and increase in the wet season. Wood and Moriniere (2013) suggest that maximum increases in temperature up to 2040 vary between 0.6 to 1.5 °C and 2.0 °C in the hottest months, rising further to 2.5 °C up to 2060. For the South of Malawi, precipitation is expected to reduce in November, increase in February and March, and decrease in April, with lower rainfall and number of days with rain. Yields of maize, the staple crop of Malawi, decrease with higher temperatures, and this reduction is intensified in drought conditions and absence of soil moisture. Late onset of rains, or late heavy rains, considerably increase the production costs of maize, as well as other crops such as groundnuts, peas and soybeans (Wood and Moriniere, 2013).

In Malawi, 71% of people live below the $1.90 poverty line, and 87% below the $3.10 a day line (OPHI, 2015). The population of Malawi largely depends on rainfed agriculture, with average land holdings of 0.42 ha per capita in rural areas (Mussa and Masanjala, 2015). Agriculture contributes around 30% to GDP, but the informal sector is much larger. Climatic variability therefore has major impacts on wellbeing (Conway et al., 2015). The drought in 2001/02 affected an estimated 2.8 million people, caused a 30% decline in maize production and resulted in a severe food crisis (Chabvunguma and Munthali, 2008). Nevertheless, the National Adaptation Program of Action has not been funded or implemented (EAD 2011, p.11).

The strategy of the Government of Malawi is to achieve sustainable economic growth through agricultural development and food security (GoM, 2009). The national Agriculture Sector Wide Plan (ASWAP, GoM, 2010) spent on average 71% of its budget from 2006 to 2013 on maize through the farm input subsidy program (FISP, FAO 2015b). Although the FISP improved maize production (Denning et al., 2009; Pauw et al., 2016, but see Lunduka et al., 2013), it may have alleviated but not reduced poverty (Arndt et al., 2016; Dorward et al., 2009). It has been associated with fraud and corruption (Hourticq et al., 2013), failed to stimulate crop diversification (Chibwana et al., 2012), and has not resulted in internationally competitive maize production (Dorward et al., 2009).

For more sustainable development in Malawi, ways to increase the performance of the agricultural sector, reduce poverty and environmental degradation have been sought in conservation agriculture and agroforestry. But government support and adoption rates among farmers are low (Kaczan et al., 2013). This has been attributed to rigid or inconsistent technical recommendations to farmers by different NGOs, clashes with other farmer livelihood activities, and low short-term revenues (Andersson and D'Souza, 2014). Alternative cereals such as millet and sorghum are seen as inferior, "crops for the desperate", whilst links between cultural preferences and political incentives for maize reduce crop diversification (Chinsinga et al., 2011).

Development practitioners in Malawi are now embracing a wider set of climate adaptation options, including water harvesting, irrigation, drought/heat resistant crops, weather forecasting and insurances (Denning et al., 2009). Besides improving farmer livelihoods and resilience, there is a case to be made for increasing agricultural productivity to reduce deforestation in catchments (MARGE, 2009). Annual rates of deforestation have been estimated between 2.8% and 3.5% (Zulu, 2010). Deforestation is linked to siltation, reduced hydropower production and water problems in urban areas (Wiyo et al., 2015). Almost all of Malawi's electricity production is hydropower, but most of the population relies on woodfuels (MARGE, 2009).

This study focused on Zomba District in Southern Malawi. Zomba has an area of 2580 $km^2$ and a population density of 230/$km^2$ and poverty rates are high. The Zomba Plateau divides the district into the Shire River Basin in the west and the Lake Chilwa Catchment Area in the east (ZDA, 2009). Most of the ten rivers in the district originate from the Plateau. Soil degradation and water depletion are the main environmental issues. Conservation agriculture is the flagship topic of the District's Agricultural Office, but most of the Office's funding is used for implementation of the ASWAP; conservation agriculture is mainly donor funded and implemented by NGOs.

## 3. Methods

### 3.1. Scenario development and trade-off analysis

Following Börjeson et al. (2006), the scenario approach taken here can be classified as a combination of explorative and normative. Explorative scenarios typically have a long time-horizon to allow for structural changes and are of qualitative nature (Börjeson et al., 2006), but defining how to achieve desirable futures is not their aim. We used an explorative approach to define the social-ecological factors that are beyond the control of the relevant actors. Normative approaches have a desired goal and chart pathways to achieve that goal. Here, we aimed to understand how the CSA and ICM objectives could be achieved under different future trajectories and to identify robust strategies.

Scenario analysis is one of many methods used in trade-off analysis for land use management, together with optimisation models, simulation techniques, empirical analyses and participatory approaches (Klapwijk et al., 2014). Where quantitative models are unavailable, qualitative scenarios can be used to analyse discrete outcomes. Qualitative trade-off analyses are particularly useful for urgent decisions with high levels of uncertainty and plural, conflicting values and may result in more legitimate and inclusive interventions (Van den Bergh, 2004).

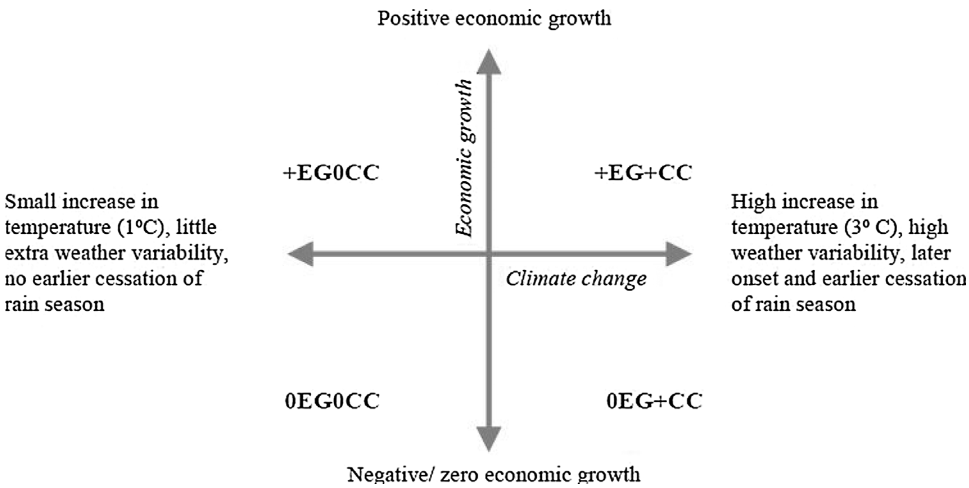


**Fig. 1.** The two axes used in the scenario analysis.
Notes: In the abbreviated scenario names, EG refers to Economic Growth and CC to Climate Change.

Analysing trade-offs through participatory scenario analysis provides critical qualitative data and expert-based judgement based on tacit knowledge (Carpenter et al., 2006).

A common method to develop qualitative scenarios is the two-axes or two-dimensional matrix approach, where the two most relevant and uncertain drivers are varied, whilst others are kept constant across scenarios. Adopting this approach, we reviewed existing scenario exercises performed in Malawi to inform the choice of scenario axes (EAD, 2010; FAO, 2013). We also conducted 14 interviews in March 2016 with experts from national NGOs, farmer organisations and district government officials. The interviews provided information on the social, political, economic and environmental factors in development and success of projects relevant to CSA and ICM.

From the interviews, we derived that "climate change" and "economic growth" were the two drivers of change that were expected to have high impact on the agricultural sector and therefore the suitability of CSA strategies, and the outlook for both is highly uncertain (Fig. 1). Economic growth determines, amongst other things, costs of farm inputs and crop revenues. The scenario analysis of the Malawian State of the Environment and Outlook Report (EAD, 2010) also used economic growth on one axis. Climate change will affect the suitability of CSA methods, as compared to conventional methods; it has been termed a "boundary condition for landscape functioning" (Minang et al., 2015, pp. 13). The temporal scope of the scenario analysis was 25 years; the spatial boundary was Zomba District.

### 3.2. Workshop

In April 2016, we organised a one-day workshop in Zomba Town to explore the impacts of CSA informed by a range of stakeholder perspectives. The workshop was attended by 24 representatives: seven from the District Government, 12 from NGOs, non-academic research organisations, and civil society organisations, one farmers organisation, and two academics. After discussing the concepts of CSA and ICM, and their goals and links, we introduced the four future scenarios. We then divided the participants into four groups and aimed to ensure that each group included experts on socio-economic and environmental topics from different organisations, who could share knowledge on the different topics.

The assessment was based on interactive sessions and discussions. Each group assessed one of the four scenarios and noted their responses on the sheets provided (see supplementary material 2). They were followed by a moderator, who provided further explanation on the exercise or concepts where necessary, intervened when the group was not progressing and took notes of the conversations. We made audio records and transcribed these for further detail and to understand reasoning behind the information provided by the respondents on the sheets.

Under each scenario, the workshop participants were asked to assess (1) a set of suitable CSA on-farm activities for small-scale farmers in Zomba District; the extent to which these activities could achieve (2) the CSA objectives and (3) the ICM objectives; (4) the impacts of these activities on wellbeing of stakeholders; (5) the trade-offs and synergies between goal achievement in CSA and ICM; (6) the key challenges to achieving the scenario outcomes and additional interventions, capacities and resources necessary to address the challenges or curb negative impacts, and (7) the prioritisation of these interventions.

Exercise 1 involved selecting six activities from a total of 26 based on Neufeldt et al. (2011), split into six categories: crops, livestock, fisheries, soil and water, agroforestry and food energy systems (see supplementary material 1). This allowed choosing at least one option from each of the six categories, which we deemed feasible to discuss and agree upon in the time available.

Exercises 2–4 involved scoring goal achievement on a scale from 'very likely to be achieved/strongly increase' (+ +), to 'very unlikely to be achieved/strongly decrease' (–). We converted the signs to numerical scores in the analysis: 2 (+ +) down to −2 (− −). In exercise 2, the three CSA objectives were: improving crop production, improving climate change resilience, and improving carbon sequestration. We split the ICM objectives in exercise 3 into three categories with four subgoals each: economic development (in the agriculture, hydropower, fisheries and forestry sectors), social development/poverty alleviation (basic needs, food security, equality, and flood risk management), and sustainable environmental management (land and soil, forests, water systems, and biodiversity). In the analysis presented here, we averaged the numerical scores over each ICM category for the sake of conciseness, but at the expense of information loss, which may not be desirable or necessary in all cases. For example, the scores for agriculture, hydropower, fisheries and forestry were combined into a single score for economic development. To select robust activities, we ranked the activities based on their selection frequency in exercise 2 and, in case of the same ranking, in exercise 3.

The stakeholder groups in exercise 4 differ in dependence on the agricultural sector in Zomba and included: farmers, off-farm workers, on-farm casual labourers, households in Zomba Town (the only urban area in the District), households beyond Zomba District, and the international community.

To understand the expected trade-offs, in exercise 5 we asked respondents to fill in a trade-off matrix (see e.g. Poirazidis et al., 2011). This novel method ensures that all CSA and ICM objectives were compared against each other one-by-one. We asked the groups to score the combinations using a + (plus) for synergies, − (minus) for trade-offs, +/− (plus-minus) when both trade-offs and synergies could occur, and 0 (zero) for neutral or unrelated goals. We converted these

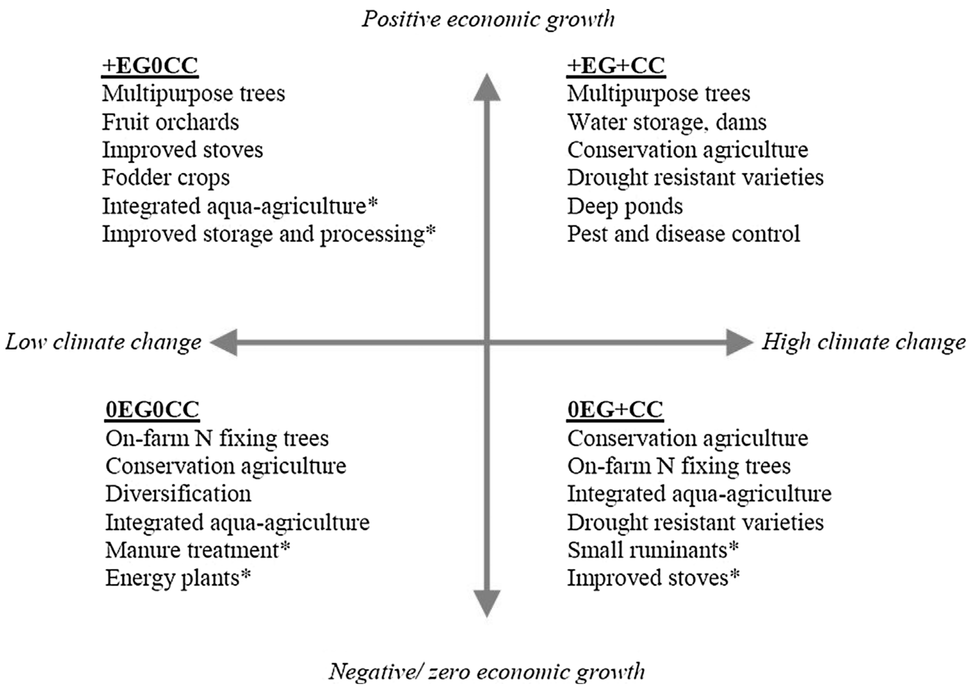


**Fig. 2.** Selected CSA techniques under each scenario. Note: CSA techniques marked with asterisks (*) have the same rank.

into numerical scores (1, −1, 0 and no score respectively) and calculated an average score for each ICM category.

In exercise 6, we asked participants to list four main challenges to achieving the CSA and ICM objectives, and to list short, medium and long-term policy actions to address these. We provided the participants with a list of off-farm CSA activities (see bottom half of supplementary material 1) for guidance. These actions were prioritised in exercise 7.

## 4. Results

### 4.1. Selected CSA techniques

In exercise 1, the groups chose 16 different techniques out of 26 options (see Fig. 2). The motivations for selection corresponded with the scenario characteristics. Conservation agriculture and integrated aqua-agriculture were selected most often (by three groups) and therefore most robust, i.e. suitable under different conditions. Conservation agriculture was not deemed necessary under the +EG0CC scenario. For the +EG+CC scenario, the group selected deep ponds for fisheries for its water storing capacity instead of aqua-agriculture. All groups selected trees, but for scenarios with positive economic growth, multipurpose trees were selected for their provision of commercial products, whilst under the zero-negative growth scenarios, on-farm nitrogen fixing trees were selected as an alternative to expensive inorganic fertiliser. Both groups with high climate change scenarios selected drought resistant varieties.

### 4.2. Achieving CSA and ICM objectives

As the CSA techniques were purposefully selected, little variation in CSA goal achievement between scenarios was reported and all scores were positive, although slightly more so in positive economic growth scenarios than with zero-negative growth (see Table 1). More variation was found in the ICM goal achievement scores, where the average scores indicate that some goals were not likely to be achieved when upscaling CSA.

The most robust CSA practices related to ICM objectives were on-farm trees, either N-fixing or multipurpose trees, which responds to the high deforestation levels in Malawi. The highest contribution of CSA to achieving ICM goals was found for the +EG+CC scenario, where yields were expected to be higher with CSA than without. But participants emphasised that in addition to trees, water storage and dams were needed for achieving ICM objectives of economic and social development. In the +EG0CC scenario, the group chose CSA activities that would complement existing staple crop systems, leading to small yield improvements and contributions to economic development. The 0EG0CC scenario group deemed achieving ICM goals of social and economic development through CSA less likely than other groups. They did not believe on-farm trees, in combination with conservation agriculture, to be effective for economic development under the 0EG0CC scenario. The overall contribution of CSA activities to ICM goals was scored lowest under the 0EG+CC scenario, especially the impact on environmental management.

**Table 1**
Impact of selected CSA activities on CSA and ICM objectives per scenario.

| CSA and ICM objectives | +EG0CC | +EG+CC | 0EG0CC | 0EG+CC |
|---|---|---|---|---|
| Yield improvement | 1 | 2 | 2 | 1 |
| Resilience | 2 | 2 | 1 | 2 |
| Mitigation | 2 | 2 | 1 | 1 |
| Economic development | 1.1 | 1.8 | 0.9 | 1.6 |
| Social development | 1.3 | 1.5 | 0.8 | 1.0 |
| Sustainable environmental management | 1.5 | 1.5 | 1.5 | 0.3 |
| Main CSA techniques | Fruit orchards, multi-purpose trees | Multi-purpose trees | On-farm nitrogen fixing trees | On-farm nitrogen fixing trees |

*Notes*: Scores are averaged over the four sub-goals of each ICM category. Each sub-goal was scored from +2 = very likely to achieved, to −2 = very likely to not be achieved.

### 4.3. Benefits across stakeholders

Benefits mentioned multiple times in the discussions of exercise 4 were food and income, whilst fuelwood, medicine and resilience were mentioned once. The results of exercise 4 suggest that overall wellbeing

was expected to increase in positive economic growth scenarios, increase only in the long-term in the 0EG0CC scenario, and decrease in the 0EG + CC scenario when CSA is implemented. Across scenarios, causal labourers and off-farm workers in rural communities were expected to benefit least, and their wellbeing was expected to decline under the 0EG + CC scenario.

Under the zero-negative economic growth scenarios, CSA activities were only expected to increase wellbeing when climate change was minor. The 0EG0CC group expected no short-term benefits except for CSA farmers, and small positive benefits in the long-term for all other groups, compared to a continuation of current practices. They reasoned that diversification and manure treatment would stabilise income and reduce the reliance on expensive chemical fertiliser. But as the prices of imported inputs rise, farmers would not be able to pay labourers and local and national communities would face higher food prices. The 0EG + CC scenario would result in high wellbeing losses (− −) for on-farm and off-farm workers, and in the long-term also negative benefits (−) for Zomba's urban population and Malawians outside Zomba; only farmers were expected to gain some long-term benefits.

### 4.4. Trade-offs

Fig. 3 presents the results of the trade-off matrix in exercise 5, where the grey scale shows synergies (white to light grey, > 0) and trade-offs (dark grey to black, ≤ 0) between goals: the lower the average score, the more trade-offs rather than synergies are expected. The diagonal values in the matrix reflect whether the sub-goals in the ICM categories were considered compatible. Trade-offs were identified between CSA objectives, between CSA and ICM objectives, and between sub-goals. Most trade-offs were indicated for higher crop production and broader agricultural sector objectives; increasing production was deemed incompatible with hydropower generation, plantation forestry and sustainable environmental management. None of the objective combinations was labelled as incompatible or synergetic across all four scenarios.

The arguably most pessimistic 0EG + CC scenario (bottom right) scored lowest: it involved a high number of trade-offs (n = 26), especially related to yields, resilience and agricultural sector development more widely. This was to be expected; when government budgets are small because of zero or negative economic growth, choices must be made between objectives. The average total scores for the scenarios with minimal climate change (0EG0CC and + EG0CC) were higher than in high climate change scenarios, meaning that more synergies were expected.

The 0EG0CC group (bottom left) identified no trade-offs (no negative scores), but argued for 19 of the combinations that the goals were unrelated or neutral (no score), 13 of which were for combinations with the equal welfare objective. The group did not see how CSA activities would help to address welfare inequality, and considered the different power relationships between men and women and the situation of young, elderly and disabled. The positive score of social development of this group hence reflects the CSA impacts on basic needs and food security. Other groups argued that the impact of CSA on social development could go either way and gave it mostly + / − scores. The + EG + CC group reasoned that the gap between rich and poor would grow and if the rich adopted CSA and increased production, the poor could potentially benefit from lower food prices even if they were not able to adopt CSA themselves. They also put forward that dams and trees could increase water availability, but that an equal distribution of water resources was not guaranteed. The + EG0CC group similarly argued that economic growth does not reduce inequality, and addressed this in exercise 6.

| | | | minimal climate change | | | | | high climate change | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CSA | | ICM | | | CSA | | ICM | | |
| | | | Resilience | Mitigation | Economic | Social | Environment | Resilience | Mitigation | Economic | Social | Environment |
| Positive economic growth | CSA | Yields | 1.00 | 1.00 | 0.50 | 0.75 | 1.00 | 1.00 | 0.00 | -0.25 | 0.75 | 0.50 |
| | | Resilience | n.a. | 0.00 | 1.00 | 0.67 | 1.00 | n.a. | 1.00 | 1.00 | 0.75 | 1.00 |
| | | Mitigation | | n.a. | 0.75 | 1.00 | 1.00 | | n.a. | 0.75 | 1.00 | 1.00 |
| | ICM | Economic | | | 0.60 | 0.79 | 0.60 | | | -0.17 | 0.81 | 0.50 |
| | | Social | | | | 1.00 | 0.69 | | | | 0.80 | 0.53 |
| | | Environment | | | | | 1.00 | | | | | 1.00 |
| Zero - negative economic growth | CSA | Yields | 1.00 | 1.00 | 0.50 | 1.00 | 1.00 | -1.00 | -1.00 | -0.67 | 0.00 | -0.50 |
| | | Resilience | n.a. | 0.00 | 1.00 | 1.00 | 1.00 | n.a. | 1.00 | 0.50 | 0.00 | -0.50 |
| | | Mitigation | | n.a. | 1.00 | 1.00 | 1.00 | | n.a. | 1.00 | -0.25 | 1.00 |
| | ICM | Economic | | | 0.75 | 1.00 | 0.69 | | | 0.33 | 0.50 | 0.56 |
| | | Social | | | | 1.00 | 0.75 | | | | 0.33 | 0.00 |
| | | Environment | | | | | 1.00 | | | | | 0.83 |

**Fig. 3.** Trade-offs and synergies between CSA and ICM objectives.

Notes: greyscale coding ranges from white for highest average scores (i.e. mainly synergetic) to black for negative average scores (i.e. involving trade-offs). Scores (+ to −) were translated into numerical values (+1 to −1) from +1 for synergies to −1 for trade-offs. Combinations deemed unrelated were given no value. For the three categories of ICM, averages over the four sub-goals were calculated.

### 4.5. Challenges and policy responses

In exercises 6 and 7, participants listed the four main challenges to achieving the CSA objectives through wider CSA implementation, and suggested suitable responses to those challenges (see supplementary material 3). Some of the interventions address barriers underlying adoption of CSA, while others aim to increase the net benefits; the policy recommendations varied in their specificity. Three groups identified lack of political will, direction and policy harmonisation. Lack of technical CSA expertise, among farmers as well as extension workers and development practitioners, was also mentioned three times. Both high economic growth scenario groups identified land availability as a main barrier, associated with a subsistence-farming trap. The two zero-negative economic growth scenario groups saw lack of market involvement as the main problem to achieving CSA objectives, which highlights the need for CSA initiatives to address off-farm processes.

We classified the suggested interventions as either community-oriented or policy-oriented. In the short-term, the groups with zero-negative economic growth scenarios would start with improving extension services, ensuring that technical agricultural advisers of different NGOs or the Government do not give contradicting advice to farmers. This response may have originated in the recent evaluation of conservation agriculture in Malawi, in which some of the participants had been involved. It is different from the response of the positive economic growth groups who preferred to start with better promotion of CSA techniques and low-investment CSA activities.

Three groups suggested household training and skills development interventions, adult literacy, youth education and livelihood diversification training, access to soft loans through village loans and saving schemes. However, while for the positive economic growth scenarios these activities were prioritised in the short-run and continued in the mid-term, groups with zero-negative economic growth scenarios focused on short-term community sensitisation to CSA and delayed adult literacy to the mid-term. The +EG0CC group emphasised mainstreaming gender issues and women empowerment through education and attitudinal change. This was deemed necessary to address poverty and ensure that the poorest and most-vulnerable people in society would be able to benefit from economic growth. This emphasis in this group may have been driven by the participation of a social policy expert, and less so by the scenario, but the group fully agreed on the importance of such actions.

The first national policy oriented intervention mentioned in three groups was lobbying for more political attention and awareness of CSA. This was combined with a review of existing policies to identify incompatibilities across sectors, followed in the mid-term by the publication of new policies or integration of existing policies, and in the long-term CSA mainstreaming into relevant policy areas. The +EG0CC group only reached consensus on prioritisation of these efforts in the long-term if problems in implementation were addressed. One participant argued that sectorial divides do not correspond to the reality of farmers. The two groups with low climate change scenarios emphasised the mid-term need for advocacy and involvement of stakeholders in policy formulation, including further engagement of local communities through bottom-up problem articulation. These groups included civil society representatives.

The +EG+CC group deemed implementation of climate policies important. The other group with a high climate change scenario but zero-negative economic growth (0EG+CC), who expected no stakeholder benefits from CSA (except for farmers in the long-term), put more emphasis on feasible, social policies, such as value addition activities and financial stimuli. Only the 0EG0CC group, who expected positive long-term effects for all stakeholders, prioritised interventions that would improve resilience and environmental management in the short-term, but also wanted to improve markets. This suggests that equitable economic development is prioritised over climate action.

The two groups with high economic growth scenarios both identified land problems as a limiting factor. The +EG0CC group advocated land consolidation and the development of rural growth centres, thereby depopulating rural areas, but believed this controversial idea only to be actionable on a longer time scale than other strategic actions.

## 5. Discussion

### 5.1. Policy implications

Our scenario analysis provides policy relevant results of the perceived suitability of CSA and the possibilities for its upscaling and integration with landscape level policies such as ICM. Tree planting, integrated aqua-agriculture and conservation agriculture were seen as the most robust on-farm CSA techniques for Zomba. Although we cannot rule out bias towards known techniques or professional interests of the participants, these CSA techniques help to improve soils, conserve water and generate marketable products. All groups recognised that CSA adoption requires short-term benefits for farmers, which is a limitation of on-farm trees. Different views on short-term incentives were expressed: the 0EG+CC group listed subsidies, but the +EG0CC group preferred soft loans and argued that any handouts would create dependencies. The participants mostly prioritised feasible, equitable economic development over environmental management and climate change mitigation. Despite the professional interests of some participants, none of the groups suggested more stringent environmental management interventions to address trade-offs.

Also noticeable was that none of the participants explicitly argued for an overhaul of the FISP. This may be because of either perceived political infeasibility or a less favourable opinion of alternative agricultural practices. Agroforestry and conservation agriculture have failed to achieve wide-scale adoption in Malawi, and inorganic fertiliser may be necessary for conservation agriculture to achieve benefits for smallholders (Vanlauwe et al., 2014), which is not ruled out under CSA. The results seem to suggest that CSA needs to complement existing maize-focused practices and participants argued that more experimentation and research on suitable CSA techniques for different agro-ecological zones and climate change patterns is needed.

The trade-off analysis made clear that without additional policies, CSA would not be able to provide in basic needs or achieve equity or food security. Lower wellbeing improvements were expected under the zero-negative economic growth scenarios. But as a +EG0CC group member argued: *"As economic growth is happening, the inequality gap is widening. Unless we have a strategy that promotes equal benefits from growth, we cannot take it for granted."* The +EG+CC group put forward that "*when it comes to implementation, […] the better-off are adopting more than the worse off. The better off will use the [CSA] techniques more than the worse-off or the poor. […] If you look at the land holdings in the villages, the poor do not have much.*"

For CSA to be successful and provide wellbeing, household strategies to empower men and women are needed. This was emphasised in both the workshop and in the preceding interviews. One +EG0CC group member highlighted that "*the Malawian literacy level is 38%, the majority of illiterate people are women… Illiteracy is contributing to inequalities*." Farmers are unlikely to adopt CSA practices without a suitable basic skill set that enables them to benefit from post-harvesting CSA techniques, even more so when organisations provide divergent information and lack understanding of households' situations and dynamics.

### 5.2. Limitations

The main limitation of the adopted scenario exercise methodology was time; one group (+EG0CC) did not manage to finish exercise 7 on prioritisation. The interaction with the workshop participants was confined to one day, except for those participants who had been

interviewed prior to the exercise. It was not within the capacity of this project to allow for a more participatory process to design the scenario exercise and its boundaries (Klapwijk et al., 2014), or to aim for ownership or implementation of outcomes (Vervoort et al., 2014).

With six CSA activities, three CSA goals, 12 ICM sub-goals and a scenario, the trade-off exercise was complex. On some occasions, mediators had to remind the groups to keep in mind either the scenario or the CSA activities when evaluating the compatibility of the goals. We relied on the expertise in the room for determining impacts. As knowledge of CSA is expanding, it may become possible for future applications to provide an overview of the experience with various CSA techniques across different locations and their goal achievement to reduce the uncertainty in the causal relationships between techniques and outcomes. However, part of the uncertainty is intrinsic, related to unknown drivers and heterogeneity among farmers and socio-ecological conditions, which needs to be recognised in strategic planning. For more accurate trade-offs assessment, one might recommend a more reductionist approach and simplify the exercise, yet this complexity is also a characteristic of real decision-making contexts warranting a holistic approach.

Assessing trade-offs between social development and environmental policies was most challenging for participants, compared to other trade-offs: one group therefore left these evaluations to the end. The large number of neutral and +/− scores may signal trade-off avoidance among decision makers (Luce, 2005; Tetlock, 2003). It can also be that these trade-offs are very complicated and require more thought.

Differences in scenario evaluations may be in part obscured by differences in group composition and backgrounds, or result from dominance of certain participants. This may be partially avoided if there is time for all groups to evaluate all scenarios. Observation of the group discussions suggests that evaluation of 'technical' agricultural options is more difficult for 'social' experts, as reflected in part by limited contribution to discussions. The opposite may also hold and explain why the relation between equity and the technical options was unclear in some discussions. Participants may not have shared the same understanding of the CSA activities, objectives or the purpose of the exercise. For example, on equal welfare, although some groups thought of targeted actions to address income, gender or age effects, one group did not recognise any connection between CSA and equality. Ideally, future applications of our methodology would allow for more time during the participatory process to build a common understanding of different concepts and approaches, including CSA, wellbeing, and equity. While some shortcomings may be overcome by the suggested methodological adaptations, other phenomena are likely to be inherent to the nature of the policy question and translate into wider participatory, interdisciplinary and cross-sectoral policy making. However, the general picture suggests that responses, scores and suggested interventions were sensitive to and coherent with the scenarios.

## 6. Conclusions

Upscaling CSA activities to landscape levels requires coordination and integration with other landscape-wide and sectoral policies. Our methodology offers an approach to discuss and critically analyse the manifold trade-offs in sustainable development policies under different scenarios, and link these to concrete policy interventions. The scenario exercise demonstrates that upscaling CSA may lead to trade-offs with social and environmental policies, most prominently in case of low government budgets (to invest in supporting activities or to address limitations) in times of zero or negative economic growth.

The results of our study suggest that successful upscaling of CSA will require investment in human and social capital, especially to support the poorest members of rural communities and achieve poverty alleviation. Governments and projects need to prioritise literacy and technical and economic skill development to empower people and start further rural economic development away from low-income activities. Where projects do not invest in human capital, emphasis on CSA is unlikely to reduce existing inequalities. The suitability and benefits of CSA activities vary across climate change scenarios and socio-ecological conditions, which means that solution must be targeted to locations and problems, but we expect our findings to hold some relevance for areas reliant on smallholder agriculture and with high illiteracy levels.

A clear and consistent policy framework is also necessary for successful adoption and upscaling of CSA, including clear guidelines, extension services, incentives and technical infrastructure, and policy harmonisation to avoid trade-offs between CSA and other social and environmental policy objectives. It will need involvement of the Finance, Social Affairs and Gender, Education, Water, Forestry and Economic Development Ministries, as well as non-governmental organisations and experts in partnership with local communities. An adaptive, participatory process could draw from existing initiatives to upscaling CSA. Our proposed approach could support such involvement, especially if applied over a longer timeframe to build a common understanding, vision and ownership. This could then be extended to translate initial, generic recommendations into a national strategy and action plan for upscaling CSA, with outcome-based targets related to CSA and wider landscape or national scale objectives.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.envsci.2017.11.007.

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